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HUMAN-INDUCED CHANGES IN BACK-BARRIER ENVIRONMENTS AS FACTORS IN TIDAL INLET INSTABILITY, WITH EMPHASIS ON FLORIDA

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PURPOSE: This Coastal and Hydraulics Technical Note (CHETN) provides general information about the consequences of human alterations of back-barrier environments on tidal inlet stability, including several examples from the Gulf Coast of peninsular Florida.

BACKGROUND: Tidal inlet morphology and stability depend on the interaction of the ocean tide at the inlet entrance with inlet channel geometry, back-barrier bay geometry, wave-generated processes, and morphology change induced by episodic storms. Depending on how these factors and processes combine, inlet hydrodynamics may include harmonic distortions to the tide that result in ebb or flood dominated currents, which in turn strongly influence the shape and extent of inlet ebb and flood shoal deposits. Inlet cross-sectional area, channel length, frictional drag, and geometry of the back bay influence tidal exchange. Small tidal inlets having narrow throat sections behave hydraulically as the balance between friction and the hydraulic pressure gradient along the inlet channel, influencing the tidal prism. In this case the relation between tidal prism and inlet throat cross-sectional area can be empirically estimated (Jarrett 1976). Substantial efforts have been made to theoretically and empirically describe the interactions among tidal inlet channel geometry, tidal prism, and the stability of a tidal inlet. In contrast, the influence of distal back-barrier geometry on tidal exchange with the ocean and the possible consequences to inlet stability have not been as well examined.

In this technical note, common anthropogenic alteration of bays, lagoons, and estuaries are reviewed in the context of possible and documented impacts on tidal inlet stability. There have been only a few observational or theoretical works that consider the relation of back bay geometry to tidal inlet dynamics and consequences for coastal engineering practice. Previous works by Boon and Byrne (1981), FitzGerald et al. (1984), and Keulegan, (1967) are noted. The goal of this note is to describe the responses of inlets to extensive alterations that have occurred in back-barrier areas of Florida during the era of rapid development during the past 80 years.

Alterations to the back bay tidal circulation can alter tidal prism at an inlet in a number of ways:

- Construction of fill-type causeways between the mainland and the barrier islands creates tidal drainage divides.

- Dredge-and-fill construction in intertidal and subtidal environments reduces both the area and the volume of water in the back-barrier bays and estuaries.

- Dredging of the navigational channels in the back-barrier causes tidal flow to be directed away from some inlets

- Tidal prism captured by a new adjacent inlet reduces the prism and stability at an adjacent inlet sharing the same water body.

All of these ways of altering tidal circulation can be associated with human activities except the last one that can result from both natural and human-related changes.

The Florida peninsula includes more than 70 tidal inlets of various sizes, morphologies, and stability. This is a complex and fragile inlet system in which about half of the inlets are artificially stabilized. The west coast is one of low-energy with a maximum mean average wave height at the shore of about 0.4 m and a mean tidal range of less than 1 m. Annual littoral drift rates range from 25,000 to 50,000 m^3 directed to the south with numerous reversals in direction (Davis 1999). This coast has about 30 inlets with a very wide range in size, morphology, and stability.

The east coast of the Florida peninsula is more energetic and homogenous in the nature of its tidal inlets. Here the mean wave height at the coast approaches 1 m depending on location. The tidal range extends from about 1 m in the south to more than 2 m at the northern boundary with Georgia. Littoral drift is uniformly directed to the south with an annual rate of near 500,000 m^3 on the north and diminishing to about 50,000 m^3 near Miami (Marino and Mehta 1993). Several of the inlets were opened by dredging, and virtually all are stabilized. Tidal prisms range over four orders of magnitude on the west coast, but are typically small on the east coast with is small lagoons, with the exceptions of those at the mouth of the St. Marys and St. Johns Rivers.

NATURAL FACTORS IN INLET CHANGE: The primary factors that may produce significant changes in inlet morphology and stability are: (1) sediment availability, (2) intense storms, and (3) change in the inlet hydraulic parameters that influence tidal prism. The inlet may become less or more stable, depending on the specific combinations of change.

Sediment Availability: Sediment delivery to the inlet by wave-generated processes may produce various changes to the inlet channel and/or the ebb delta. Most examples of changes in sediment delivery are related to impoundment of littoral sands by jetties constructed to stabilize inlets for navigation or other structures designed to impound sand for shore protection. There are only a few situations where the natural rate of sediment delivery to and along the coast can significantly change. An example is the significant increase in sediment availability from the response to changes in the benthic environment along the northern section of the barrier/inlet system of the Gulf Coast of the

Florida peninsula. This low-energy shoreface and nearshore area was covered with sea grass through the late 1950s, as shown by aerial photographs. The loss of this sea-grass community released sediment and made it possible for waves to transport it to the nearshore (Hine et al. 1987). Large amounts of sediment have accreted along several kilometers of barrier coast, and one inlet has experienced a change as the result. It is the inlet at the south end of Anclote Key, the northernmost barrier in this system. Progradation of the southern end of the barrier is in the process of transforming this inlet from a wave-dominated one to a mixed-energy, offset inlet

Storms: Tropical and subtropical storms are a major factor along the Gulf and South Atlantic coasts. The vulnerability of the ebb-tidal delta to such intense storms and the resulting modifications to it by storms can cause major changes to inlets. In addition, such storms can produce inlets where they did not previously exist. These storms can also reopen previously closed inlets.

Low-lying barriers such as along the Texas and Louisiana, and Gulf peninsula coast of Florida are susceptible to overwash during severe storms. This phenomenon can open new inlets in two ways. The relatively large channels associated with washover fans can accommodate a significant tidal prism that will cause further increase in the channel size and create a tidal inlet. This occurred as the result of Hurricane Elena on the Florida coast in 1985, when a small inlet, Willys Cut, developed (Davis et al. 1989). The other method of inlet formation is caused by the combination of increased barometric pressure and the seaward return of storm surge after the passage of the cyclonic storm. This seaward flow of water can cut channels that eventually carry a significant tidal prism, creating a tidal inlet. Depending on the tidal prism these storm-generated inlets may or may not survive. Willys Cut lasted only 6 years, and dozens of storm passes formed on the Texas coast as the result of Hurricane Alicia in 1980 but they lasted only months. In contrast, Redfish Pass, Florida was formed in 1921 and is still in a natural state (Figure 1). Johns Pass, formed by a hurricane in 1848 (Figure 2) is still functioning in a stable condition although there has been construction of short jetties on both sides of the channel.

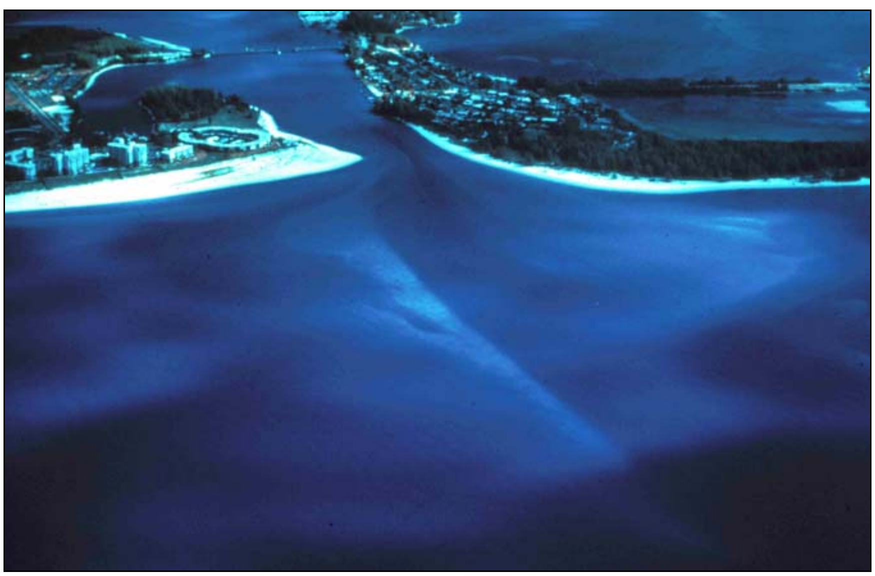

Figure 1. Redfish Pass, a tide-dominated inlet formed by a hurricane in 1921

Change in Tidal Prism: An increase in tidal prism available to an inlet will cause it to hydraulically adjust and, commonly, to increase in cross-section area. Decrease in tidal prism can induce instability of an inlet, reduction of channel cross-section, and perhaps eventual closure. These changes can be brought about by both by natural causes and human activities.

Breaching of a barrier and the subsequent formation of a new tidal inlet is the most common circumstance whereby substantial changes in tidal prism occur. Typically, the new inlet captures some of the prism from the adjacent inlet or inlets. There is a single maximum potential prism for any back-barrier system because neither the area of the water body or the ocean tidal range is changed. The outcome is that the new inlet must share the existing prism with any adjacent inlets.

Figure 2. Blind Pass, 1999, a good example of an unstable wave-dominated inlet

The presence of a new inlet forms new tidal divides that partition the tidal prism, with different possible consequences to the inlet hydrodynamic system. One possible result is that the new inlet will capture much of the tidal prism and cause the adjacent inlet or inlets to have a reduced prism and become unstable. An example of this occurred after the formation of Johns Pass on the Florida coast. Indian Pass to the north eventually closed, and Blind Pass on the south became unstable and migrated nearly 2 km before being artificially stabilized (Figure 2). Blind Pass has been small and unstable since the first accurate charts of the late 19th century. However, a large flood shoal suggests that the inlet has been significantly larger in the past. A different situation takes place on the Texas coast where storms have opened Corpus Christi Pass and Packery Channel many times over the years. Both of these ephemeral inlets are located several kilometers south of Aransas Pass, the main inlet having a maintained deep-draft channel servicing the large tidal prism from Corpus Christi Bay. These shallow storm passes are incapable of capturing any of the tidal prism from the larger inlet and, therefore, are closed by littoral drift shortly after being opened.

HUMAN-INFLUENCED INLET CHANGES: The first major construction practice that altered tidal inlets was their stabilization by jetties and revetments. Causeway construction between the mainland and the barrier islands began in the mid-1920s. Coastal development in Florida increased greatly after World War II, and in the 1950s and 1960s there was extensive dredge-and-fill construction for purposes of adding land that would support houses. The last major project in the back-barrier area was the dredging of the Intracoastal Waterway (ICW) in the 1950s and 1960s along most of the Gulf of Mexico and Atlantic Ocean coasts.

Coastal systems, especially barrier-inlet systems, are dynamic. Changes that take place in one element of this system will nearly always bring about a responding change in other of the elements. This is especially true for the Florida Gulf Coast barrier-inlet systems because the low wave energy allows tidal processes to dominte at some locations. Because tidal inlets are dependent upon the flux of tidal waters through them for their existence, they represent one of the most fragile elements of a barrier-inlet system.

Sometimes these changes are related to the natural processes discussed above, but many of the most severe changes are the result of various types of construction activity. All of these development factors have important but indirect, and sometimes subtle, influence on tidal inlets. Much of the information presented below is an elaboration on a paper by Davis and Barnard (2000).

Causeway Construction: The easiest and most economical way to construct roads from the mainland to barrier islands is by dredging material from the estuaries and bays landward of the barrier and placing the borrow material as fill for the road bed (Figure 3). Boat traffic was provided for by including small openings with lift bridges. Some causeways also have additional small bridges to increase circulation and thereby address the problem of water quality. No attention was paid to tidal circulation behind the barrier or between the open coast and the back-barrier bays. Such barriers present artificial tidal divides between inlets. Construction of these causeways began in the early 1920s, and within one or two decades nearly all barrier islands had at least one such thoroughfare connecting it with the mainland.

These causeways were, in effect, dams across the back-barrier areas that partitioned the open water and severely limited the tidal flux that could pass through them. As a consequence, the tidal prism of various inlets was changed significantly. Because of the large number of causeways, the typical effect was partitioning of the tidal prism, leading to a reduction in inlet stability and subsequent migration of the inlet along the open coast. This condition reduces inlet cross-section and/or closure of the inlet by littoral sediment. The littoral sediment cannot be adequately flushed from the inlet mouth due to slower currents generated by the flux of the reduced tidal prism. This situation caused the need for many of the inlets to be stabilized by structures to maintain navigation and keep some of the inlets from closing.

Figure 3. Clearwater Causeway connecting the mainland with the nearby barrier island

Fill causeways are also present between the mainland and barrier islands in other states such as Texas, Alabama, Louisiana, and Georgia. In these situations there are fewer islands connected to the mainland and where there is a connection, there is only one causeway per island. The combination of this situation and the large tidal prisms in most of the back-barrier areas has resulted in little impact on nearby inlets.

Solution: Fill causeways have given way to causeways elevated by pillars. The natural tidal circulation in the back-barrier environments can be returned by replacing existing fill causeways with these elevated roadways. Although the cost of converting such causeways is great, there are efforts underway to do just that. The cost-benefit analyses seem to be encouraging.

Dredge and Fill: As the barrier islands became completely developed, there was pressure for more space on which to place homes and commercial properties. The solution of the time (1950s) was to dredge from one area and fill in another, thereby creating buildable upland property in areas that were originally intertidal or subtidal environments. The typical result was a series of elongate upland areas separated by finger canals (Figure 4) that were produced from dredging of what was previously mangrove communities and/or seagrass beds.

Figure 4. Typical back-barrier area in Florida showing dredge-and-fill development

In most situations, this type of development took place at the expense of the intertidal communities that fringed both the back barrier and the mainland such as salt marshes and mangrove mangals. Destruction of these environments was a major setback to the coastal ecosystem. Some of the upland areas were developed on shallow subtidal environments that are productive and important to the ecosystem. The other major problem for the ecosystem is the deterioration of water quality due to poor circulation in the finger canals, and from runoff of nutrients from the developed uplands where fertilizers, herbicides, insecticides, and vehicular discharges can make their way into the adjacent coastal water. All of these factors have caused deterioration of the coastal ecosystem.

Such dredge-and-fill land development practices have had a major negative impact on the tidal inlets in the coastal system. In some areas, the dredge-and-fill land development practices caused substantial decrease in the water area of the back barrier, bringing a major reduction in the tidal prism flowing through individual inlets. This also led to inlet instability and the potential for migration and/or closure.

In Boca Ciega Bay, one of the most highly developed back-barrier areas along the west-central part of the Florida coast, there was a reduction in surface area of 28 percent while such construction practices were allowed (Mehta, Jones, and Adams 1976). The reduction in bay area can be seen from comparison of the first accurate map of the area in 1883 with that from just over a century later in 1997 (Figure 5).

Although both coasts of Florida are replete with this type of construction it also has taken place in other areas, but on a modest level. The area on the landward side of Padre Island, Texas has some dredge-and-fill construction, but it has little influence on inlets, only reducing water quality in the area. Surprisingly, there are areas on the northeast coast of the north island of New Zealand that started such development in the early 1990s, despite lessons learned in Florida.

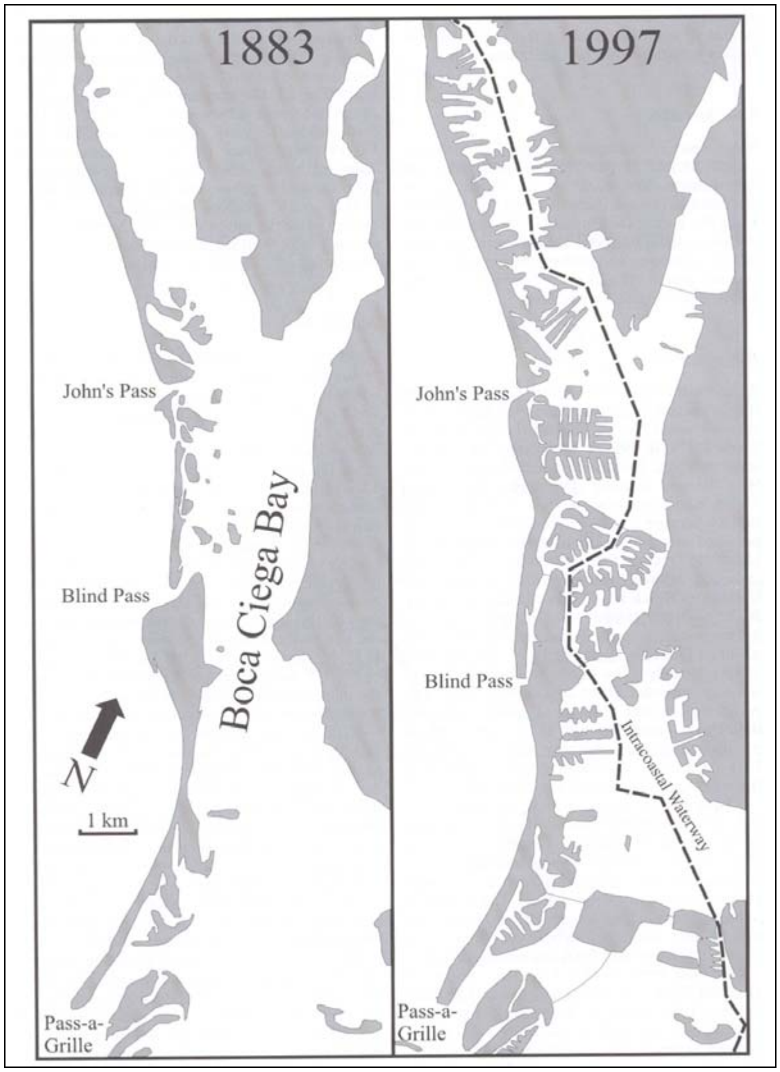

Figure 5. Boca Ciega Bay area, 1883 and 1997 (Davis and Barnard 2000)

Solution: There is no practical approach for eliminating already constructed finger canals and related dredge-and-fill construction in the back-barrier environment. Future dredge-and-fill projects should be considered only after full hydrodynamic and stability analyses have been performed.

Intracoastal Waterway: Commercial boat traffic is a central part of the commerce along most coasts, especially so for the Gulf and Atlantic coasts of the United States. The need for a protected waterway and the presence of the extensive barrier island system along these coasts led to the decision to dredge and maintain an inland waterway (the ICW) along these back-barrier waters. The design for the channel at most locations was a depth of 8 ft (2.4 m) and a width of 50 ft (15.3 m), although in many regions such as for Texas, Louisiana, and Florida the waterway is wider and deeper. Dredging was primarily by suction dredge with sidecast disposal along the margins of the channel. This construction style created small islands that have became chabit for birds, seagrass, and other organisms, as well as amenities for fishing.

Along the Texas and northern Gulf Coast, the ICW (or Gulf Intracoastal Waterway – GIWW) is dominated by commercial traffic, but recreational vessel usage dominates the Florida and Atlantic ICW system. The channel did, however, bring some negative consequences. Construction of the dredged-material islands further decreased the potential tidal prism by reducing the water area of the back barrier. However, this effect is small. Another influence of these small islands is the alteration of circulation by their presence. The more problematic impact is the channelization of tidal flow along the path of the waterway, particularly in narrow back-barrier bays such as Little Sarasota Bay on the Florida Gulf coast. This condition has the effect of transferring tidal prism from some inlets to others. Especially debilitated are small inlets that did not have a natural or dredged channel connection to the ICW.

Solution: Consider problematic areas when maintenance dredging is necessary. Allowing some areas to accumulate sediment in the channel, if feasible for navigation, can diminish its influence on directing tidal flux along shore. This approach might permit a channel to remain at 5-6 ft (1.5-1.8 m) depth instead of 8 ft (2.4 m) depth. In addition, channels can be dredged from the ICW to problem inlets to assist in their stability. New tools have made it possible and economical to optimize navigation projects for minimum impact on inlet stability. The U.S. Army Engineer Research and Development Center sponsored the development of an advanced circulation (ADCIRC) model for oceanic, coastal, and estuarine waters, Luettich, Westerink, and Scheffner (1992). The ADCIRC modeling system provides accurate prediction and convenient visualization of circulation in back bay areas and inlet hydraulics. Special features of the ADCIRC modeling system that are particularly applicable to back bay areas include wetting and drying of tidal flats, overflow and throughflow at physical barriers, and inclusion of bridge piers in the model domain (Luettich and Westerink 1999a, 1999b).

CASE HISTORIES: Some specific examples of significant change caused, at least in part, by human activity can demonstrate how each of the factors discussed above have contributed to inlet deterioration along barrier coasts. In some situations there has been a combination of both natural processes and anthropogenic influences, and in others the human activities are the primary responsible contributor.

Dunedin Pass, Florida: At the beginning of the 20th century, Dunedin Pass (Figure 6) was a large inlet called Big Pass having a cross-sectional area of 1,200 m^2 (Lynch-Blosse, and Davis 1977). In 1921, a hurricane with a storm surge of about 3 m caused a breach in what was Hog Island forming Hurricane Pass only 3.5 km north of Dunedin Pass. This new inlet rapidly became fairly stable, persisting as a natural inlet since its formation (Lynch-Blosse and Davis 1977). Only 5 years later, in 1926, the causeway between the city of Clearwater and Clearwater Beach Island was completed, creating an artificial tidal drainage divide. Both of these events, one natural and one human-induced, altered the tidal prism of Dunedin Pass (Big Pass). The opening of an inlet only a few kilometers away captured some of the tidal prism of Dunedin Pass. The prism was further reduced at nearly the same time by the construction of the causeway that partitioned the coastal bay serving Dunedin Pass. As a result, there was a rapid reduction in the cross-sectional area of the inlet (Figure 7).

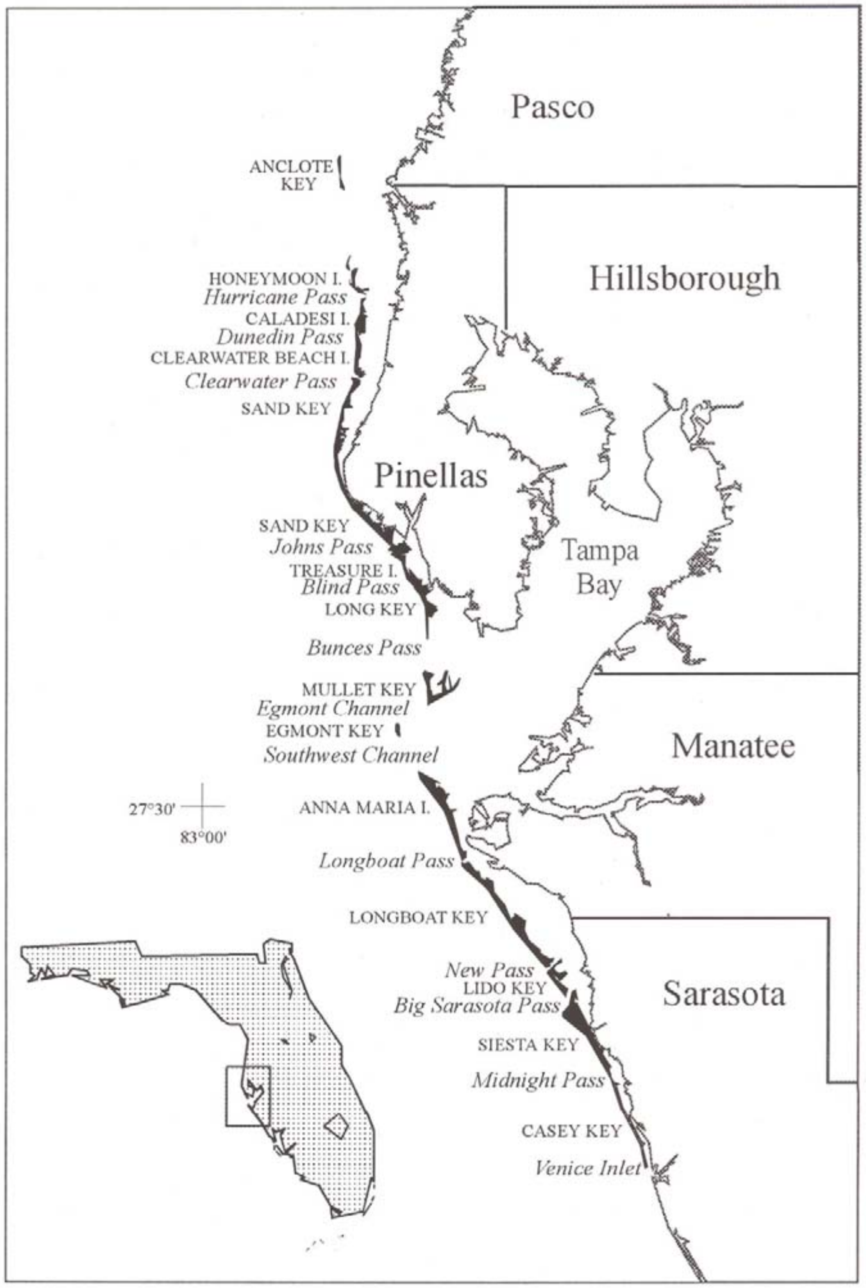

Figure 6. West-central coast of Florida and locations of barrier islands and inlets

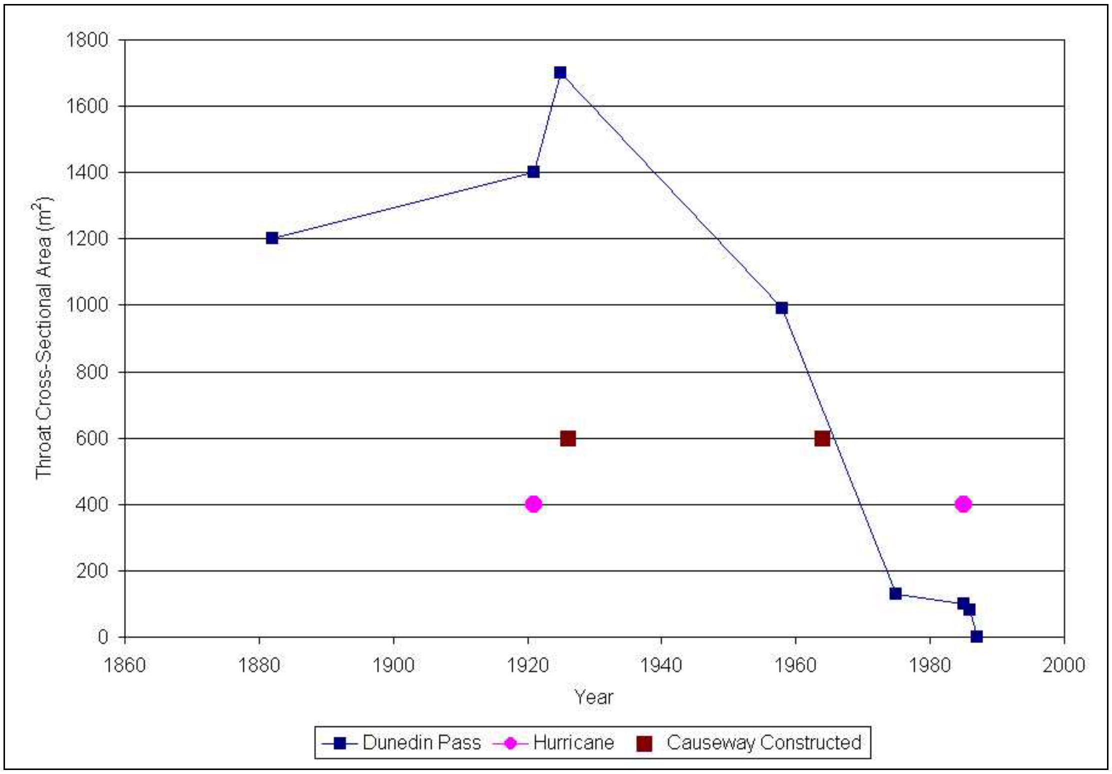

Figure 7. Changes in the cross-sectional area of Dunedin Pass since the late 19th century

Decades later, in 1964, another causeway was completed connecting the mainland at Dunedin to Honeymoon Island north of and adjacent to Hurricane Pass. This further compartmentalized the back-barrier bay and further reduced the tidal prism available to Dunedin Pass. The reduction in cross-sectional area continued (Figure 7) so that by 1975, the inlet had been reduced to only about 10 percent of its size from 100 years previous.

The final event that led to the closure of Dunedin Pass was the passage of Hurricane Elena in 1985. Although this storm did not make landfall near the inlet in question, it did generate enough wave energy to remove the ebb-tidal delta that existed at the mouth of the inlet (see Figure 8a). By this time the inlet channel was only about 50 m wide and 1.5 m deep with a small tidal prism. After removal of the ebb delta, the northward moving littoral drift along Clearwater Beach Island to the south caused the channel to fill within 3 years (Figure 8b). The absence of severe storms and their associated surge in between removal of the ebb delta and final closure, contributed to the trend for closure. The inlet has remained closed for the past decade with sediment being added regularly through washover during the passage of winter cold fronts.

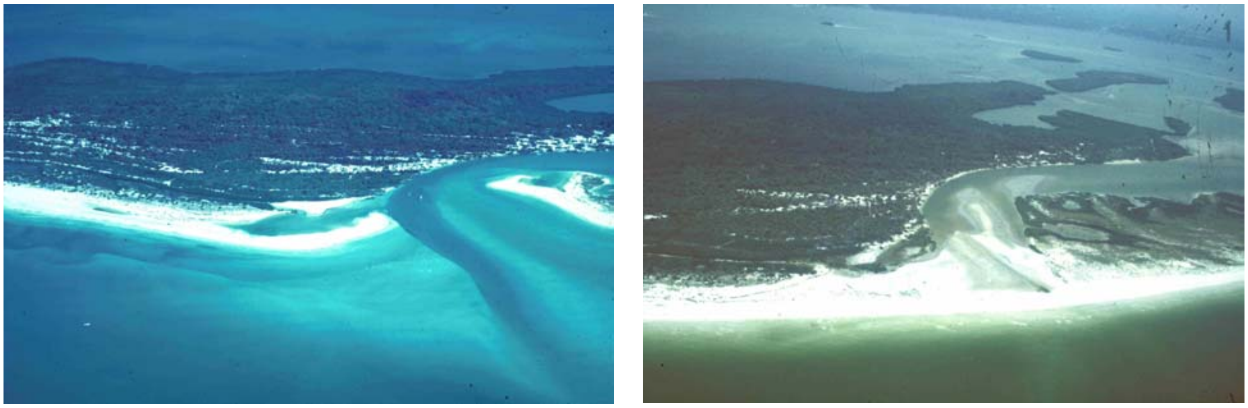
(a) (b)

Figure 8. Dunedin Pass (a) in 1979 as a mixed-energy inlet with a prominent ebb delta and (b) in 1990, 2 years after closure

This is an example of how both human activities landward of the barrier system coupled with natural phenomena have contributed to close a once large, mixed-energy tidal inlet.

Solution: A combination of changes would allow the opening and stability of Dunedin Pass. At least a partial reconstruction of the Dunedin and Clearwater causeways to elevated status plus a dredged channel connecting the inlet with the ICW might be sufficient. The range of possible solutions could be verified by ADCIRC simulations of the tidal circulation. The main question is whether this action is in the best interest of the now-closed inlet. Plans to open it have been abandoned.

Blind Pass, Florida: Blind Pass (formerly called Boca Ciega Pass) separates the barriers Treasure Island and Long Key (see Figure 6). In the middle of the 19th century, this tidal inlet was larger that at present although we have no information prior to the charts of the late 19th century and the 1926 photographs. The presence of a large flood tidal delta suggests that it was larger prior to this time, and was located directly Gulfward of its flood-tidal delta. After the hurricane of 1848 formed Johns Pass 5 km to the north, there was a marked reduction in the size and stability of Blind Pass because the new inlet had captured a large amount of the tidal prism in Boca Ciega Bay. As a result, the inlet began to migrate rapidly to the south so that by 1926, the time of construction of the nearby causeways, the mouth had moved substantially to the south (Figure 9) as a result of increasing influence of littoral drift over the diminished tidal prism. The present location of the inlet is nearly a mile south of the 1873 location based on the survey of that date. By 1937, another causeway had been completed. A rubble jetty was constructed that year on the south side of the channel (Mehta, Jones, and Adams 1976). Within a short time thereafter, extensive dredge-and-fill construction landward of the barrier islands adjacent to Blind Pass began. The large decrease in surface area of Boca Ciega Bay (Figure 5) caused by this type of construction further decreased the tidal prism at Blind Pass. During most of the time that Blind Pass was experiencing a decrease in tidal prism and therefore, in cross-sectional area, Johns Pass was becoming larger at its expense (Figure 9). It can be seen from the time-series of inlet size (Figure 10), that there has been little change in the area of the combined inlets.

After stabilization of Blind Pass and continued dredge-and-fill construction, the inlet had such a small tidal prism that littoral drift from the north accumulated in the channel threatening closure. A north jetty was constructed in 1962, but the fillet exceeded its length in only a few years. This structure was extended in the late 1960s to control erosion losses from the south end of Treasure Island to the north. There is still considerable infilling of the inlet because its small tidal exchange cannot keep the channel free of sediment accumulation. The down-drift beach has been deprived of sediment after the extensive stabilization and requires nourishment periodically. Much of that nourishment material is taken from the accumulated sediment in the mouth of the inlet.

Both natural and anthropogenic factors have contributed to the instability of Blind Pass. Stabilizing the inlet has not solved the problem and has resulted in chronic downdrift erosion at the highest rate on the Florida Gulf Coast. Nourishment of the downdrift beach (Upham Beach) is required at about 3-year intervals.

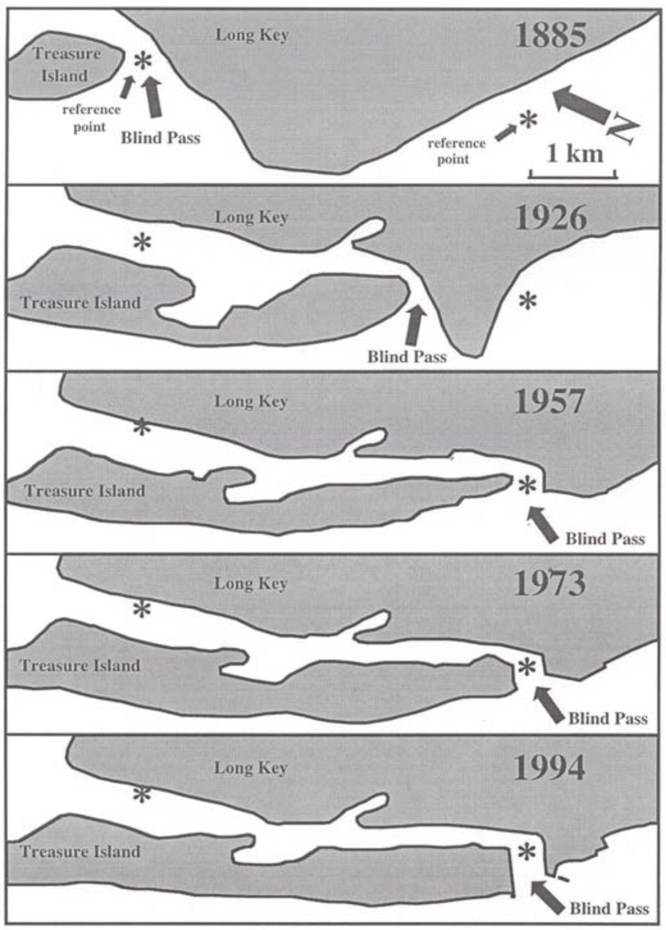

Figure 9. Migration of Blind Pass (Boca Ciega Pass) since the late 19th century

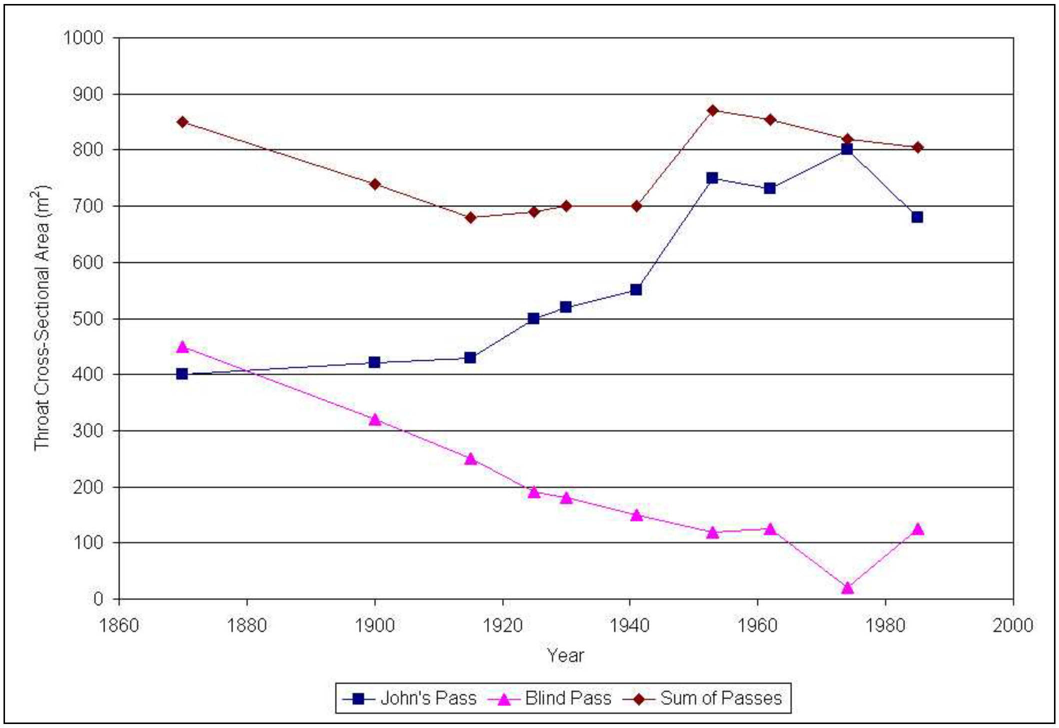

Figure 10. Time-series showing the changes in inlet cross-sectional area for Johns Pass and Blind Pass (after Mehta et al, 1976)

Solution: Two different approaches can be proposed for the problems created by the instability of Blind Pass. One is to remove the structures and allow the pass to close as it did naturally in 1978. Its functions now are primarily for access by small recreational vessels and to improve water quality through its channel. Modification of the fill causeways in Boca Ciega may increase tidal exchange if combined with regular dredging of the inlet to maintain a significant prism. The year 2000 dredging was to a greater depth 16 ft (5 m) than previous work, and the channel has not accumulated significant sediment in more than a year. It is also possible that modification of the causeway may not offset the frictional reduction in current by the long conveyance channel to Blind Pass. Thus, evaluation of this situation through numerical simulation of the tidal hydraulics would quantify the benefits of alternative solutions and their combination.

Midnight Pass: Historically, a small inlet has separated Siesta Key on the north from Casey Key on the south in Sarasota County, Florida (Figure 6). This inlet, Midnight Pass, has a history of being unstable (Figure 11) and migrated to the north of 2.5 miles (4 km) during the early 20th century (Davis et al. 1987). The tidal prism was typically modest at best because the inlet served only Little Sarasota Bay, a narrow back-barrier bay that has constricted natural connection to larger Sarasota Bay to the north.

Figure 11. Midnight Pass in 1983 just before closure.

This narrow and shallow bay had several elongate oyster reef complexes along its length whose orientation and configuration perpendicular to the shoreline (Figure 11) indicated that at least some tidal currents moved along the length of the bay, and not simply in and out of Midnight Pass. Oysters receive their nourishment from suspension feeding, which means the most efficient organization is to stretch across the currents that are carrying the suspended nutrient material.

In the early 1950s, some dredge-and-fill construction took place associated with the oyster reefs. Sediment was dredged from the floor of the bay and filled over the oyster reefs, creating small peninsulas extending into the bay and oriented perpendicular to the adjacent shoreline both on the mainland and on the landward side of the barrier islands (Figure 12). At this time (1954), Midnight Pass was at its maximum size in recorded history with a width of 130 m and a maximum depth of 13 ft (4 m). A modest sized ebb-tidal delta was also present indicating that the inlet had a tidal prism sufficient to keep the channel open and in a fairly stable position (Davis and Gibeaut 1990).

The ICW was constructed along this part of the Florida Gulf coastline from 1963 to 1964. This inland channel extended the length of Little Sarasota Bay and was dredged between the small dredge-and-fill peninsulas. It enhanced tidal circulation along the length of the bay by providing a pathway that captured tidal prism from Midnight Pass. Flooding tides entered the bay through the inlet, but exited at either end through the ICW. This rerouting of flow may have eliminated or reversed the ebb dominant asymmetry of tidal currents through Midnight Pass reducing its capability to flush out sediment that was accumulating from the northerly littoral drift in this area. Within a decade or so there was significant reduction in the size of the inlet channel and considerable migration of the channel to the north (Davis et al. 1987). The inlet eventually closed in 1984.

The combination of the dredge-and-fill construction over pre-existing oyster reefs with the dredging of the ICW captured most of the tidal prism of Midnight Pass and eventually closed it as it remains today. In this situation, at least some of the cause of the closure of the inlet can be attributed to anthropogenic activities in the back-barrier area.

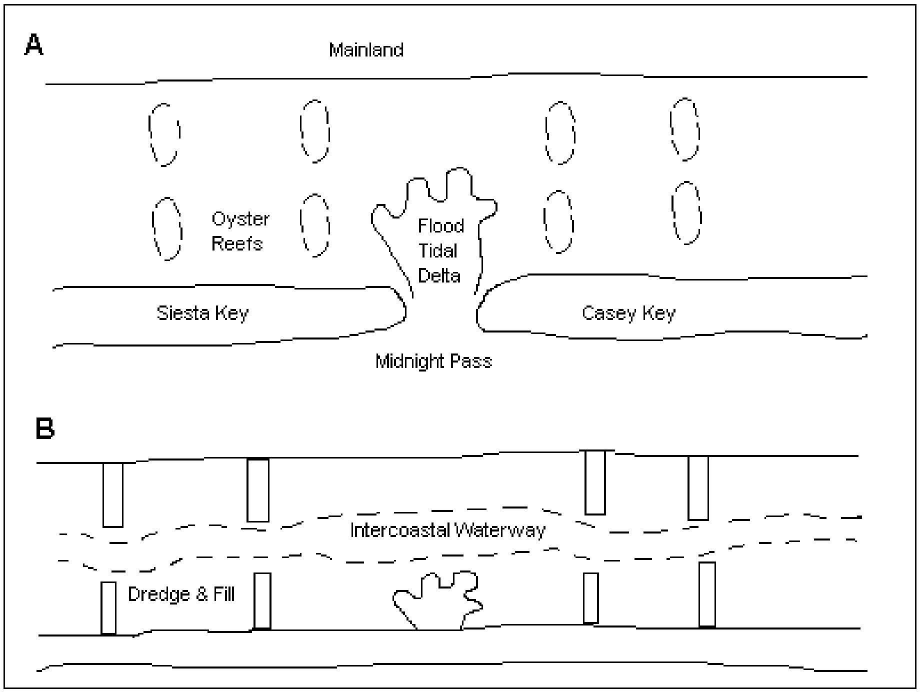

Figure 12. Little Sarasota Bay area (a) in its natural condition and (b) after dredge-and-fill construction over the oyster reefs and dredging of the Intracoastal Waterway

Solution: At least three actions could be considered to return Midnight Pass to the status of a viable inlet. First, maintenance dredging of the ICW must be done only in critical areas where navigable depths are not present. Second, the peninsulas that penetrate into Little Sarasota Bay might be removed to improve tidal exchange and minimize the channelization of tidal currents caused by the ICW. Third, a channel might be dredged from the ICW to the inlet. There is presently a continuing debate about opening this inlet with the primary focus being toward improving water quality in the bay. A major factor in this consideration is whether the inlet can maintain itself without stabilization by hard structures. Application of the ADCIRC modeling system to evaluation back bay circulation and inlet hydraulics could determine which action or combination of actions, if any, would result in a stable inlet.

Fish Pass, Texas: Numerous inlets on the east coast of Florida have been artificially cut and stabilized to keep the inlet open. The large rate and unidirectional nature of the littoral transport, coupled with the rather small tidal prisms, contribute to requirement of stabilization of many of the Florida inlets. The small tidal prisms typical of many of these inlets are a consequence of the narrow inlet channel that are narrow and small in cross-section by design in combination with elongate and small back-barrier bays.

A similar situation and a detailed monitoring of an artificial inlet cut in 1972 on Mustang Island along the central Texas coast provide a good case history example and has been discussed in another CHETN (Rosati and Kraus 2000) with regard to maintenance of entrance channels. The Texas Parks and Wildlife Department formulated a plan for cutting through Mustang Island to create pathway for migration of fish and shellfish into and out of Corpus Christi Bay. This controversial plan was not intended to support boat traffic.

The inlet, named Fish Pass, was located about 2.5 miles (4 km) up (NE) the coast from Corpus Christi Pass, an unstable and mostly closed inlet. It was also about 5 miles (8 km) south of Aransas Pass, one of the largest inlets on the Texas coast carrying nearly the entire tidal prism from Corpus Christi Bay and adjacent estuaries. The location and design of the inlet was partly the result of land acquisition situations. It was less than 6.6 ft (2 m) deep and had an elbow about two-thirds of the distance from the Gulf. The Gulf end of the inlet was stabilized with parallel, riprap jetties.

The result was that the combination of the small tidal prism, large rate of southwesterly littoral drift, and abrupt bend in the path of the inlet as well as its relatively long length of about 1.9 miles (3 km) compounded by aeolian transport of sand dredged from the channel, caused closure (Figure 13) in only a few years (Watson and Behrens 1977). As a consequence of these problems and the recognition that this inlet was never going to remain open for a significant length of time, the decision was made to abandon its maintenance, and the inlet closed completely after about 8 years.

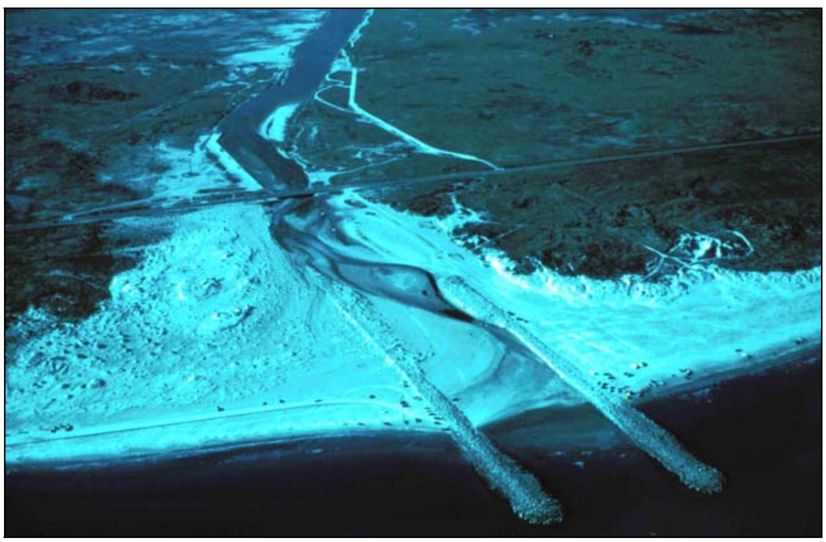

Figure 13. Aerial photo of the Fish Pass, Mustang Island, Texas (1983) showing its configuration and the sediment accumulation in the channel

Solution: The only viable solution to the problem here is the one that has been accomplished. The inlet remains closed with no proposal for its reopening.

SUMMARY: Barrier-inlet systems are fragile and central elements of the coastal zone. The maintenance of the inlets that connect the ocean with protected bays and estuaries must be managed carefully and with consideration for the long-term future of the coastal system. Inlet management has not proceeded properly along many of developed coasts and especially in Florida. Pressure for development has led to the redesign and construction of the back-barrier environments with grave consequences to the inlets.

Such practices as fill causeway construction, dredge-and-fill construction, and dredging of channels have combined to reduce tidal prism at many inlets. The result has been an increase in inlet instability that is nearly always accompanied by both a decrease in inlet cross-section and promotion of channel or inlet migration. The instability requires stabilization that further complicates the situation. The end result has been closure of some inlets and erosion of down-drift beaches of those that have been stabilized. In some cases, natural phenomena, such as storms opening inlets, have also contributed to the instability of adjacent inlets.

Although the construction of fill causeways and dredge-and-fill development have been stopped, the damage has been done and prohibitive costs will not permit corrections to be made. At present, there is considerable discussion about the merits of maintenance dredging of the ICW because of its consequences to the back-barrier environment. Consequences can be positive or negative, depending on the environmental resource, commercial value, and recreational value under consideration. Tools such as the ADCIRC modeling system can provide quantitative information to optimize dredging and retrofit projects in back-barrier environments for improved circulation and minimal impacts on tidal inlet stability.

ADDITIONAL INFORMATION: This study is a product of the Inlet Geomorphology and Channel Evolution and Inlet Channels and Adjacent Shorelines Work Units of the Coastal Inlets Research Program (CIRP) being conducted at the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory. This CHETN was written by Dr. Richard A. Davis, Jr., Distinguished University Professor, Department of Geology, University of South Florida, and by Dr. Gary A. Zarillo, Professor, Florida Institute of Technology. Reviews and additional material were provided by Mr. David V. Schmidt, U.S. Army Engineer District, Jacksonville. Questions about this CHETN can be addressed to Dr. Davis at **rdavis@chuma.cas.usf.edu** or to Dr. Nicholas C. Kraus, CIRP Program Manager, at **Nicholas.C.Kraus@erdc.usace.army.mil**.

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